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(54) Image recording system and apparatus therefor.

(57) In order to record excellent gradient image by using ink of different densities, image data for dark ink and that for light ink are generated in accordance with the received image data. The generated data for dark ink is converted into a binary signal which is

suitable for reproducing the resolution, while data for light ink is converted to another binary signal which is suitable for expressing gradient. In accordance with these binary signals, the discharge of each ink is controlled so as to record the image.

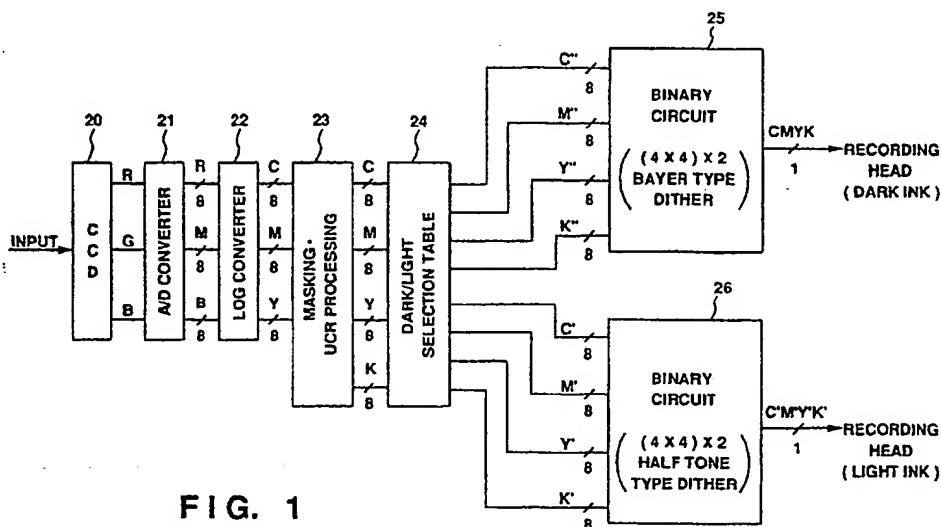


FIG. 1

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## IMAGE RECORDING METHOD AND APPARATUS THEREFOR

BACKGROUND OF THE INVENTION

The present invention relates to an image recording method and an apparatus therefor, for example, to an image recording method and an apparatus therefor for recording an image by a recording head which discharges ink.

Hitherto, in an apparatus for reproducing a binary image by a digital processing, such as a copying machine, a printer, a facsimile or the like, collapse of dots becomes excessive in highlight portions and considerable granular touch in the dots cannot be prevented when an image such as a photograph, a print or a picture in which dark and light gradients are finely expressed is recorded.

However, the conventional image processing technology cannot sufficiently overcome the above-described problems. Accordingly, a dark/light multi-valued recording method in which dark and light ink are employed in a liquid jetting recording apparatus (a so-called ink jet printer) has been disclosed in U.S.P. 4,672,432.

According to this dark/light multi-valued recording method, the gradient in the highlight portion can be improved, the granular touch of the dots can be reduced and the image quality can thereby be improved simply by changing the binary processing for a trinary processing. The reason for this lies in that applying low density ink to the highlight portion can remove the noise due to a sole dot.

Each of the output signal levels after separated by a dark/light separation table is supplied to a binary circuit in which it is converted into an on/off recording signal. The binary circuits are arranged to have the same structure for both dark and light ink.

However, in the above-described recording method depending upon the dark/light multi-valued processing, there has been a limitation to quintuple value processing due to the quantity of ink to be applied. Furthermore, since the dots for the dark ink and light ink are arranged to have the same diameter and the same binary circuits are provided in the apparatus, the excessive granular touch of the dots of the dark ink cannot be prevented if dark ink is applied to a region printed with light ink in the highlight portion.

Furthermore, in a color recording apparatus employing four color components C (cyan), M (magenta), Y (yellow) and K (black), the granular touch of K and M cannot be prevented. In particular, the skin color region such as the face of a person displays excessive granular touch due to the masking and UCR (Under Color Removal) con-

ditions in the image processing. The problems of the type described above also arises in the other recording apparatus in which toner or donor film for a thermal printer is employed.

SUMMARY OF THE INVENTION

Accordingly, an object of the present invention is to provide an image reproducing method from which an output image can be recorded in which granular portion is removed and high resolution and high gradient are realized.

In order to achieve the above-described object, an image recording method according to the present invention arranged such that high density dots are recorded by raising its resolution with respect that for the low density dots.

According to the present invention, there is provided an image recording method for recording a gradient image by combining dots of different density, comprising: a process in which image data is received; a process in which data corresponding to dots of each density is generated in accordance with the value of the received image data; and a process in which data corresponding to the thus generated dots of each density is converted so as to have resolution which corresponds to the dots of each density.

Another object of the present invention is to provide an image recording apparatus capable of recording an output image in which granular touch can be prevented and which exhibits excellent resolution and gradient.

In order to achieve the above-described object, according to the present invention, there is provided an image recording apparatus for recording a gradient image by combining dots of different density, comprising: receiving means for receiving image data; data generating means for generating data which corresponds to the dots of each density in accordance with the value of the image data received by the receiving means; and conversion means for converting each data which corresponds to the dots of each density generated in the data generating means so as to have resolution which corresponds to the dots of each density.

According to the present invention, there is provided an image recording apparatus for recording a gradient image by combining dots of different density, comprising: receiving means for receiving image data; data generating means for generating data which corresponds to the dots of each density in accordance with the value of the image data

received; compensating means for compensating data which corresponds to the dots of each density generated in the data generating means in a proportion which bases upon the resolution of each of the densities; recording means for recording the image in accordance with the resolution for each of the densities; and control means for controlling in such a manner that data which corresponds to the dots of each density compensated by the compensating means is recorded by the recording means.

Another object of the present invention is to provide an image recording apparatus for recording image by discharging ink of different densities capable of recording an output image without granular touch and exhibiting high resolution and gradient.

In order to achieve the above-described object, according to the present invention, there is provided an image recording apparatus for recording a gradient image by combining dots of at least two different densities, comprising: receiving means for receiving image data; first data generating means for generating image data for dark ink in accordance with the value of the image data received by the receiving means; second data generating means for generating image data for light ink in accordance with the value of the image data received by the receiving means; first conversion means for converting the image data for dark ink generated by the first data generating means into a binary signal with the resolution made critical; second conversion means for converting the image data for light ink generated by the second data generating means into a binary signal with the gradient made critical; and recording means for controlling the discharge of ink of each density in accordance with the binary signal converted by the first and second conversion means and recording the image.

According to the present invention, there is provided an image recording apparatus for recording a gradient image by combining dots of a plurality of different densities, comprising: receiving means for receiving image data; data generating means for generating image data which corresponds to ink of each density in accordance with the value of the image data received; compensating means for compensating image data generated by the data generating means in such a manner that image data for high density ink is subjected to higher compensation rate; conversion means for converting image data for each ink of each density compensated by the compensating means into a binary signal; recording means for recording ink in such a manner that the higher the density of the ink is, the larger the resolution becomes; and control means for controlling in such a manner that the

recording means performs the recording in accordance with the binary signal for each ink of each density converted by the conversion means.

Other and further objects, features and advantages of the invention will be appear more fully from the following description.

## BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a block diagram which illustrates an image processing system according to a first embodiment of the present invention;

Fig. 2A illustrates a Bayer type dither matrix;

Fig. 2B illustrates a tone type dither matrix;

Fig. 3 illustrates the conversion characteristics of a dark/light separation table according to the first embodiment of the present invention;

Fig. 4 is a block diagram which illustrates an image processing portion according to a second embodiment of the present invention;

Fig. 5 illustrates the matrices for the error diffusion method according to the second embodiment of the present invention;

Fig. 6 illustrates a portion around a carriage in a printing portion according to a third embodiment of the present invention;

Fig. 7 is a block diagram which illustrates an image processing portion according to the third embodiment of the present invention;

Fig. 8 illustrates the conversion characteristics of a dark/light separation table according to the third embodiment of the present invention;

Fig. 9 is a block diagram which illustrates the printing portion for recording the image; and

Figs. 10A and 10B are flow charts for illustrating the operation of the CPU shown in Fig. 9.

## DETAILED DESCRIPTION OF THE EMBODIMENTS

Preferred embodiments of the present invention will now be described in detail with reference to the drawings.

According to the embodiments, a description is made about a copying machine having a printing mechanism bubble jet printer. Since the principle of the bubble jet printer has been disclosed in U.S.P. 4,723,129, its description is omitted here. The structure of the bubble jet printer according to the embodiments of the present invention has 8 recording heads therein. The recording heads are mounted on a carriage at a predetermined interval, the carriage performing the main scanning operation. Furthermore, each of the 8 recording heads has a predetermined number of nozzles in the sub-

scanning direction.

As for record writing ink, each of recording color components C (cyan), M (magenta), Y (yellow) and K (black) is arranged to have dark tone and light tone.

Fig. 1 is a circuit diagram for processing an image performed in a copying machine according to this embodiment.

Reflected light obtained by applying halogen light or the like to a document placed on a document plate (omitted from illustration) is received by a CCD 20 which is a sensor for each of the color components via a rod lens array. The CCD 20 outputs analog data for each of the color components R (Red), G (Green) and B (Blue). Data for each of the color components is held in a sample hold circuit for a predetermined time. Each of the voltage levels thus held is, by an A/D converter 21, converted into 8-bit digital data. Then, each of data is logarithmically converted into C, M and Y data (8 bits respectively) by a log converter 22. Then, thus obtained 8-bit C, M and Y data is subjected to a masking and a basic color removal in a masking/UCR processing portion 23 so that colors C, M, Y and K (8 bits) are obtained.

Although the signal is processed as described above, all of general image processing procedure can be employed in the present invention.

Data for colors C, M, Y and K are fetched by a dark/light separation table 24 disposed next to the masking/UCR processing portion 23. The dark/light separation table 24 receives, for example, data for color C and outputs data C' (8 bits) for light ink and data C'' for dark ink after dividing the data for color C. Data for the other color components are similarly outputted after divided into data for dark ink and light ink. The dark/light separation table 24 is a so-called "Look-up" table and the detailed operation will be later.

Data for light ink (C', M', Y' and K') outputted from the separation table 24 are distributed to a binary circuit 26, while data for dark ink (C'', M'', Y'' and K'') are distributed to another binary circuit 25.

The binary circuit 25 binarizes supplied dark ink data Y'', M'', C'' and K'' for one pixel by its bayer type binary matrix pattern having a structure  $(4 \times 4) \times 2$  as shown in Fig. 2A. The above-described bayer type binary matrix pattern is one of binary matrix patterns exhibiting an excellent resolution based on the organizational dither method. Similarly, the binary circuit 26 binarizes supplied light ink data Y', M', C' and K' by its half tone binary matrix pattern having a structure  $(4 \times 4) \times 2$  as shown in Fig. 2B. The half tone binary matrix pattern is one of binary matrix pattern exhibiting excellent gradient expression capability based on the organizational dither method. Then, each of data is outputted in the form of data (a one bit

signal) for turning on/off a recording head.

Since the recording head for dark ink and that for light ink are disposed away from each other and the recording heads for each of the color components are also disposed away from each other, recording head on/off data outputted from the binary circuits 25 and 26 are synchronized to one another by a delaying buffer (omitted from illustration).

Then, the method of making the dark/light separation table 24 will now be described.

First,  $17 \times 17$  patches are formed by combining dark and light ink in such a manner that the quantity of the dark ink is classified into 0 to 16 degrees to which 0 to 16 degrees of light ink are added respectively. That is patches of the type in which light ink is changed with respect to the quantity degree "0" of the dark ink are prepared. Furthermore, patches corresponding to other dark ink quantity degrees "1 to 16" are prepared. Then, each of the batches is colorimetrically analyzed by using a "Color Analyzer CA-35" manufactured by Murakami Shikisaisha.

The, thus obtained density data is plotted as the change of data for light ink with the dark ink fixed so that the relationship between the combination of the dark and the light ink and the density is obtained. According to this embodiment, the combination of data for the dark and light ink was obtained with which a linear relationship can be established between the sole color input data and the result of the colorimetric analysis. The conversion graph of the dark/light separation table 24 thus obtained is shown in Fig. 3, where symbol C represents the separation characteristics with respect to cyan. The other color components are processed similarly to the above-described process.

The separation of the cyan data C will now be specifically described.

That is, if the value of the 8-bit data C supplied from the masking/UCR processing portion 23 is in a range between 00 and 150, data C'' for the dark ink is fixed to "0", while data C' for the light ink is outputted in the range between 0 and 255. If the supplied data is in a range between 150 and 255, the data C'' for the dark ink is outputted in the range between 0 and 255, and the data C' for the light ink is outputted in range between 255 and 0.

Similar conversion tables are prepared for the other color components M, Y and K. As a result, the dark/light separation table 24 according to this embodiment includes 4 look-up tables having characteristics as shown in Fig. 3.

According to this embodiment, higher dye density ink is used when the input data represents high density with excellent resolution maintained in the result of the recording.

As for the dye density of C-ink, 0.7%-light ink and 2.5% dark ink were employed. As for colors M, Y and K, the tables having the conversion characteristics which meet the corresponding characteristics of the colors were employed. However, the density of the dye in the dark ink and the light ink for each of the color ink are as follows:

In the case of M: light: 0.6% dark: 2.5%

In the case of Y: light: 0.7% dark: 2.0%

In the case of K: light: 1.0% dark: 3.0%

The recording order of the dark ink and the light ink was arranged as dark → light. And the recording order of the color components was arranged as C → M → Y → K so as to overlap successively. The present invention is not limited to the above-described order and the dye density. They may be changed to meet the type of the image to be outputted or the type of the dye employed. However, if the density of the dye for the dark and the light ink is changed, the conversion characteristics of the dark/light separation table must, of course, be changed.

Then, color photograph (silver salt) images or half tone image (175 lines) were outputted, resulting an excellent productionality obtained in the skin color portions and the thin lines portions of characters.

Then, a second embodiment of the present invention will now be described.

According to the first embodiment, dark ink data and light ink data for each of the color components are received so as to be subjected by the dither processing in the binary circuits 25 and 26. At this time, data for dark ink is binarized by the dither matrix patterns exhibiting an excellent resolution, while data for light ink is binarized by the dither matrix exhibiting excellent gradient expression capability.

However, the present invention is not limited to the above-described description. For example, a structure may be employed in which data for dark ink is binarized by the error diffusion method and data for light ink is binarized by the density pattern method.

Fig. 4 is a block diagram for use in the above-described case. Referring to the drawing, reference numeral 41 represents an image processing circuit including the CCD 20 to the masking/UCR processing portion 23 shown in Fig. 1. Reference numeral 42 represents a dark/light separation table which is the same as that represented by reference numeral 24 shown in Fig. 1. Reference numeral 43 represents a binary circuit acting on the basis of the density pattern method and 44 represents a binary circuit acting on the basis of the error diffusion method.

For example, a matrix shown in Fig. 5 is used in the above-described error diffusion method. Re-

ferring to the drawing, symbol "" represents a subject pixel and the numerals in the matrices represent the diffusion coefficients. Since the processing according to the density pattern method and the error diffusion method are well known, their descriptions are omitted here.

Then, a third embodiment of the present invention will now be described in which a monochrome image is reproduced.

According to the third embodiment of the present invention, a black ink quadruple recording is realized by arranging the types of the ink to be light ink (dye density: 0.5%), medium ink (dye density: 1.0%) and dark ink (dye density: 3.0%).

Fig. 6 is a perspective view which illustrates a cartridge of a type in which a dark, a medium and a light ink cartridges are integrally provided.

Referring to the drawing, reference numeral 5 represents a light ink cartridge, 9 represents a medium ink cartridge and 6 represents a dark ink cartridge. The image can be formed when a carriage 7 on which the above-described three cartridges are moved in the main scanning direction as designated by an arrow shown in the drawing. Therefore, the ink applying order is arranged as: dark, medium and light.

The above-described apparatus is arranged in such a manner that the dark ink cartridge 6 is connected to a head displaying a recording density of 400 dpi, the medium ink cartridge 9 is connected to that displaying a recording density of 300 dpi and the light ink cartridge 5 is connected to that displaying a recording density of 200 dpi. The recording side of the recording head of each of the cartridges 6, 9 and 5 has a plurality of ink discharging port (nozzles) arranged vertically to form a line. The ration of the number of the nozzles for the recording head for the light ink, that for the medium ink and that for the dark ink is arranged to be 2:3:4 so as to correspond to the resolution. The distance between the adjacent nozzles provided on the recording head for the light ink is arranged to be twice of that for the dark ink. The distance between the adjacent nozzles provided on the recording head for the medium ink is arranged to be 1.5 time that for the dark ink. As a result of the above-described structure, the resolution in the sub-scanning direction can be determined.

The control of the resolution in the main scanning direction is performed by controlling the timing of a ink discharge instruction signal (an operation signal) to be supplied to each of the recording heads. Assuming that the carriage 7 moves at a constant speed, it is arranged that the number of the operation signals to be supplied to the medium ink recording head per unit time is 3f, that supplied to the dark ink recording head per unit time is 4f when the number of the operation signals to be

supplied to the light ink recording head per unit time is 2f. The carriage according to the first embodiment of the present invention has 8 cartridges shown in Fig. 6.

An example of the structure of the image processing circuit for the apparatus according to a third embodiment is shown in Fig. 7.

Referring to the drawing, reference numeral 71 represents a circuit to be subjected to the same processings as those subjected to the image processing circuit 41 shown in Fig. 4. Reference numeral 72 represents a dark/medium/light separation table which receives input data for K (8 bits) and generates data (8 bits) for dark, medium and light ink. The data for K supplied through the image processing circuit 71 according to the third embodiment of the present invention display a resolution of 200 dpi.

Data for light ink separated by the dark/medium/light separation table 72 is, as it is, fetched by a light ink binary circuit 73 in which it is converted into an on/off signal with which light ink is applied. That is, it is outputted to the light ink binary circuit 73 with maintaining the same resolution as that at the time of the input.

Data for medium ink is converted from data for a resolution of 200 dpi to data for a resolution of 300 dpi by a conversion circuit 76 so as to be fetched by a medium ink binary circuit 74.

Data for dark ink is converted from data for a resolution of 200 dpi to data for a resolution of 400 dpi by a conversion circuit 77 so as to be fetched by a medium ink binary circuit 75.

The above-described conversion circuits 76 and 77 are constituted by compensating circuits for performing an compensating processing by using the adjacent pixel data items. Assuming that image data (pixel data) to be supplied to a time series is A, B, C, D,..., the conversion circuit 76 outputs data in a sequential order as A,  $(A + B)/2$ , B, C,  $(C + D)/2$ , D,..., while the conversion circuit 77 outputs data in a sequential order as A,  $(A + B)/2$ , B,  $(B + C)/2$ , C,  $(C + D)/2$ , D,... The ratio of the compensation, that is the ratio between the number of the output pixels and the number of the input pixels is made coincide with the ratio between the resolution. That is, when an image of 200 dpi is received and an image of 300 dpi is outputted, the total number of the output pixels in the lateral direction is arranged to be 1.5 times the total number of the input pixels. The vertical pixels are subjected to a similar processing. Since the conversion circuits 76 and 77 also compensate the sub-scanning direction, each of the conversion circuits 76 and 77 includes a line memory having a proper capacity.

Fig. 9 illustrates an example of an imaging circuit positioned behind the binary circuits 73 to 75 according to this embodiment.

Referring to the drawing, reference numerals 91 to 93 represent buffer memories for temporarily storing image data supplied from the binary circuits 73 to 75. Reference numerals 94 to 96 represent latches for holding binary information to be recorded by an operation signal. Reference numeral 100 represents a driver for outputting the operation signal to signal lines 100a, 100b and 100c at the above-described timing.

Then, the operation when the carriage 7 performs one scanning action will now be described with reference to a flow chart shown in Fig. 10.

When a CPU 90 detects that image for one scanning operation of the carriage 7 has been stored in each of the buffer memories 91 to 93, the CPU 90 causes the driver 102 to move the carriage 7. In step S2, it is determined whether or not a dark ink recording head 99 of the carriage 7 has reached a position at which the recording starts. The above-described determination is arranged to be made by whether or not a sensor fixed to the printing portion has detected a specific portion of the carriage 7. It may, of course, be made by another means. If it is determined that the carriage 7 has been moved to the dark ink image recording start position, the CPU 90 instructs the driver 100 to start generation of operation signals to be supplied to the dark ink recording head 99 via the signal line 100c. When the level of the signal line 100c has become active, the dark ink recording head 99 performs one action of discharging ink liquid in accordance with information latched by the latch 96. Whenever the above-described operation has been completed, next image data is arranged to be read by the latch 9 from the buffer memory 93.

In steps S4 to S7, the CPU 90 controls the start of the medium ink recording. The reason for the fact that the recording start time is different for the types of ink lies in that the recording heads are disposed at predetermined intervals.

Thus, the carriage 7 gradually moves for performing the scanning operation. As a result, the dark ink recording head 99 first reaches the recording end position. In step S8, the determination of this is made. If the determination is YES in step S8, the flow advances to step S9 in which the generation of the operation signal for the dark ink recording is stopped. Then, in steps S10 to S13, similar operation is conducted for the medium and the light ink recording heads. In step S14, the carriage 7 is then moved in the reversed direction so as to reach its home position and as well recording paper 1 is fed in the scanning direction by a distance corresponding to the one scanning recording action.

As described above, the recording heads 97 to 99 are positioned away from one another. In order

to adjust the time delay due to the above-described positions, the read from each of the buffer memories with respect to one scanning recording is arranged to be delayed before latched by each of the latches.

Although the operation signals to be supplied to the recording heads are generated in the driver 100 according to the above-described embodiments, the operation signals may be arranged to be outputted from the CPU 90. The reason for this lies in that the number of predetermined clocks may be counted so as to generate the operation signals.

Conversion characteristics of the dark/medium/light separation table 72 according to the third embodiment of the present invention are shown in Fig. 8.

As shown in Fig. 8, when the value of the input 8-bit data is in a range between 0 and 80, both data for the medium ink and that for the dark ink are made "0" to which light ink data 0 to 255 are made correspond. The range in which input data is between 80 and 180 is assigned to light ink and medium ink, while dark ink is made correspond to "0". A range exceeding 180 is assigned to medium ink and dark ink, while light ink is made "0".

As a result, a portion in which a multiplicity of solid black sections present, for example, characters or the like can be expressed with displaying an excellent resolution. Furthermore, a highlight portion image exhibiting an excellent gradient and without granular touch can be obtained. The above-described binary circuits 73 to 75 are arranged based on the dither method.

Although the structure of the printing portion according to the first and the second embodiments are omitted from a detail description, it can be considered to be substantially the same as that according to the third embodiment of the present invention shown in Fig. 9 except for the number of the recording heads. According to the first and the second embodiments, since the difference in the resolution is expressed by means of the binary processing, a structure can be employed in which the nozzles for each of the recording heads are disposed at the same intervals. The difference from the third embodiment lies in that the operation signals are supplied to the recording heads at the same intervals.

Other embodiments of the present invention will now be described.

According to the above-described first to the third embodiments, the description is made on the assumption that the ink discharging nozzles for the recording head have the same inner diameter (the diameter of the orifice). However, a structure may be employed in which orifices of  $30\text{ }\mu\phi$  for dark ink and those of  $40\text{ }\mu\phi$  are used. In order to express

the dark and light images by employing the same orifice diameter, the warmtone of the heads is changed. That is, the warmtone is arranged to be low for the dark image, while the same is arranged to be high for the light image so as to change the diameter of the droplets (the diameter of the droplets are, of course, made to be small for the dark image and large for the light image). As an alternative to the two types of dark and light ink, three or more density ink and recording heads may be employed. However, it is preferable in this case that the highest dye density be made correspond to the greatest resolution by using the separation table. The above-described method can be widely applied to general methods such as changing of the head recording density and the changing by means of a pseudo gradient. The dark and light ink are not necessary for all of the color components and they may be adjusted so as to meet the desired image. Furthermore, assuming that the dark/light integrated cartridge is used, it is preferable that the shape of the cartridge be designed suitably. The present invention is effective not only in the color image reproduction but also in monochrome image reproduction.

Although the description is made about an ink jet printer, and more particularly is made about a bubble jet printer, the present invention may be applied to another type piezoelectric type printer. Furthermore, it may be applied to a printer capable of forming dots of two or more densities.

As described above, according to the present invention, an excellent quality image exhibiting excellent resolution and gradient without granular touch in the highlight portions can be obtained.

Although the invention has been described in its preferred form with a certain degree of particularly, it is understood that the present disclosure of the preferred form has been changed in the details of construction and the combination and arrangement of parts may be resorted to without departing from the spirit and the scope of the invention as hereinafter claimed.

## Claims

1. An image recording method for recording a gradient image by combining dots of different density, comprising the step of: recording is performed in such a manner that resolution for high density dots is raised with respect to that for low density dots.

2. An image recording method according to claim 1, wherein said low density dots are recorded with said gradient raised with respect to that for said high density dots.

3. An image recording method for recording a

gradient image by combining dots of different density, comprising:  
 a process in which image data is received;  
 a process in which data corresponding to dots of each density is generated in accordance with the value of said received image data; and  
 a process in which data corresponding to the thus generated dots of each density is converted so as to have resolution which corresponds to said dots of each density.

4. An image recording method according to claim 3, wherein each of said processes is provided for recording color components.

5. An image recording apparatus for recording a gradient image by combining dots of different density, comprising:

receiving means for receiving image data;

data generating means for generating data which corresponds to said dots of each density in accordance with the value of said image data received by said receiving means; and

conversion means for converting each data which corresponds to said dot of each density generated in said data generating means so as to have resolution which corresponds to said dots of each density.

6. An image recording apparatus according to claim 5, wherein said conversion means comprises: first binary means for binarizing data of said image data generated by said data generating means which corresponds to said high density dots so as to raise its resolution; and second binary means for binarizing data of said image data generated by said data generating means which corresponds to said low density dots so as to raise its resolution.

7. An image recording apparatus according to claim 6, wherein said first binary means is binary means employing a bayer dither matrix, while said second binary means is binary means employing a half tone dither matrix.

8. An image recording apparatus according to claim 6, wherein said first binary means is binary means based on an error diffusion method, while said second binary means is binary means basing upon a density pattern method.

9. An image recording apparatus according to claim 6, wherein said receiving means, said data generating means and said conversion means are respectively provided for components of color image to be recorded.

10. An image recording apparatus for recording a gradient image by combining dots of different density, comprising:

receiving means for receiving image data;

data generating means for generating data which corresponds to said dots of each density in accordance with the value of said image data received;

compensating means for compensating data which corresponds to said dots of each density generated in said data generating means in a proportion which bases upon the resolution of each of said densities;

recording means for recording the image in accordance with said resolution for each of said densities; and

control means for controlling in such a manner that data which corresponds to said dots of each density compensated by said compensating means is recorded by said recording means.

11. An image recording apparatus according to claim 10, wherein said compensating means compensates data for said dots of each density generated in said data generating means in accordance with each resolution.

12. An image recording apparatus according to claim 10, wherein said recording means records said high density dots with large resolution and records said low density dots with small resolution.

13. An image recording apparatus according to claim 10, wherein said recording means comprises recording heads by the number corresponding to the number of types of ink having different densities and each of said recording heads has nozzles for discharging ink and disposed at intervals which correspond to their resolution.

14. An image recording apparatus for recording a gradient image by combining dots of at least two different densities,

comprising:

receiving means for receiving image data;

first data generating means for generating image data for dark ink in accordance with the value of said image data received by said receiving means; second data generating means for generating image data for light ink in accordance with the value of said image data received by said receiving means;

first conversion means for converting said image data for dark ink generated by said first data generating means into a binary signal with the resolution made critical;

second conversion means for converting said image data for light ink generated by said second data generating means into a binary signal with the gradient made critical; and

recording means for controlling the discharge of ink of each density in accordance with said binary signal converted by said first and second conversion means and recording the image.

15. An image recording apparatus according to claim 14, wherein image data for dark ink generated by said first data generating means is generated when the density of said received image data by said receiving means exceeds a predetermined density value, said image data for dark ink



being generated in proportion to the density of said received image data.

16. An image recording apparatus according to claim 14, wherein image data for light ink is generated by said second data generating means in proportion to the density of said received image data when the density of said received image data is lower than a predetermined density level, while the same is generated in proportional to the density of said received image data when said density of said received image data exceeds a predetermined level.

17. An image recording apparatus according to claim 14, wherein said first conversion means is binary means employing a bayer dither matrix, while said second conversion means is binary means employing a half tone dither matrix.

18. An image recording apparatus according to claim 14, wherein said first binary means is binary means basing upon an error diffusion method, while said second binary means is binary means based on a density pattern method.

19. An image recording apparatus according to claim 14, wherein said receiving means, said data generating means and said conversion means are respectively provided for components of color image to be recorded.

20. An image recording apparatus for recording a gradient image by combining dots of a plurality of different densities, comprising:

receiving means for receiving image data;  
data generating means for generating image data which corresponds to ink of each density in accordance with the value of said image data received;  
compensating means for compensating image data generated by said data generating means in such a manner that image data for high density ink is subjected to higher compensation rate;  
conversion means for converting image data for each ink of each density compensated by said compensating means into a binary signal;  
recording means for recording ink in such a manner that the higher the density of said ink is, the larger said resolution becomes; and  
control means for controlling in such a manner that said recording means performs the recording in accordance with said binary signal for each ink of each density converted by said conversion means.

21. An image recording apparatus according to claim 20, wherein said recording means records said high density dots with large resolution and records said low density dots with small resolution.

22. An image recording apparatus according to claim 20, wherein said recording means comprises recording heads by the number corresponding to the number of types of ink having different densities and each of said recording heads has noz-

zles for discharging ink and disposed at intervals which correspond to their resolution.

23. An image recording apparatus according to claim 20 further comprising said receiving means, said data generating means, said conversion means and said control means respectively provided for components of color image to be recorded.

24. An image recording apparatus or method in which an image is recorded by forming dots of a first optical density, and forming dots of a second optical density, the dots of the first optical density having a finer resolution than the dots of the second optical density.

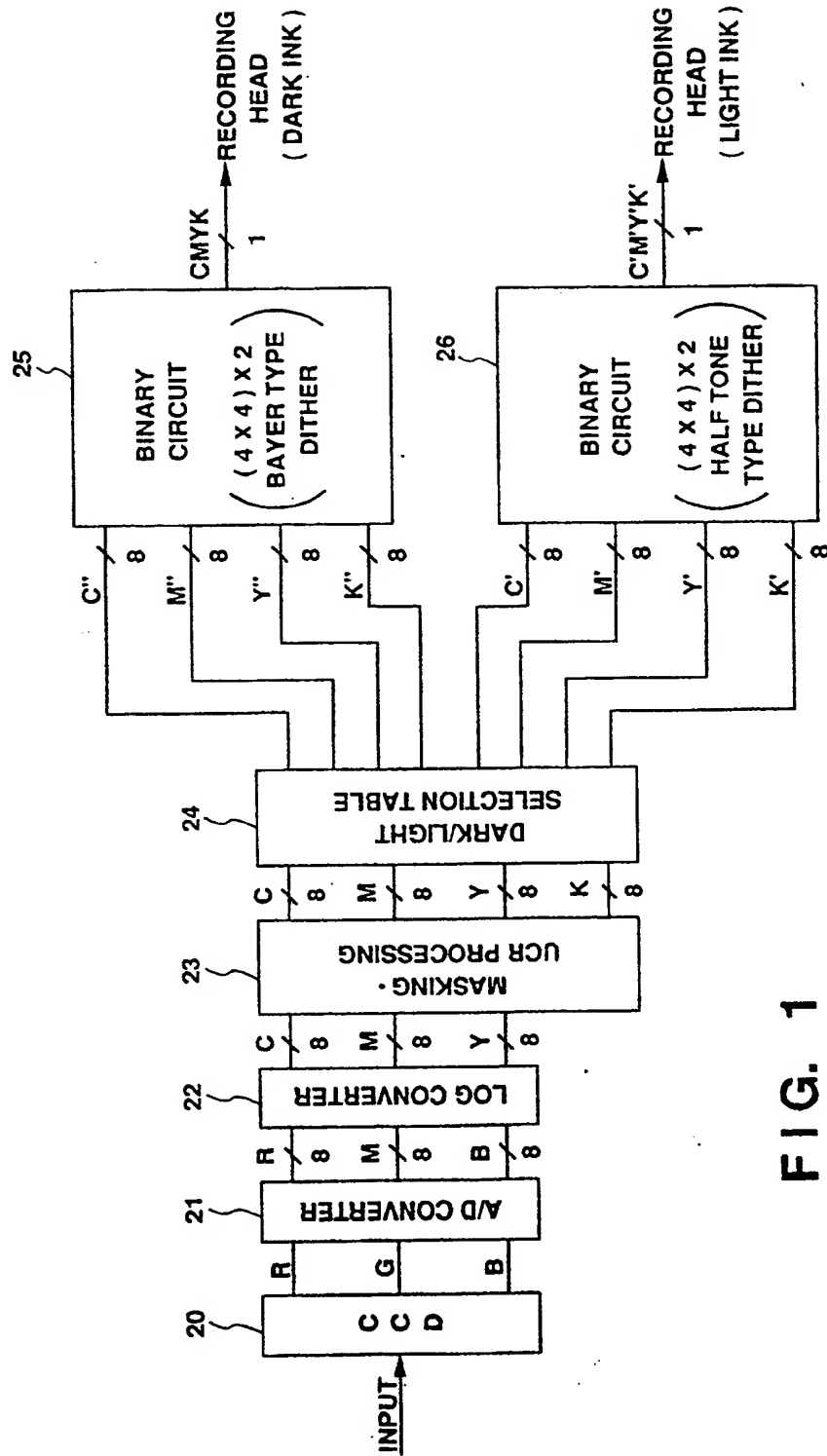


FIG. 1

1	33	9	41	3	35	11	43
49	17	57	25	51	19	59	27
13	45	5	37	15	47	7	39
61	29	53	21	63	31	55	23
4	36	12	44	2	34	10	42
52	20	60	28	50	18	58	26
16	48	8	40	14	46	6	38
64	32	56	24	62	30	54	22

FIG. 2A

45	17	25	37	47	19	27	39
49	1	9	57	51	3	11	59
29	33	41	21	31	35	43	23
13	61	53	5	15	63	55	7
48	20	28	40	46	18	26	38
52	4	12	60	50	2	10	58
32	36	44	24	30	34	42	22
16	64	56	8	14	62	54	6

FIG. 2B

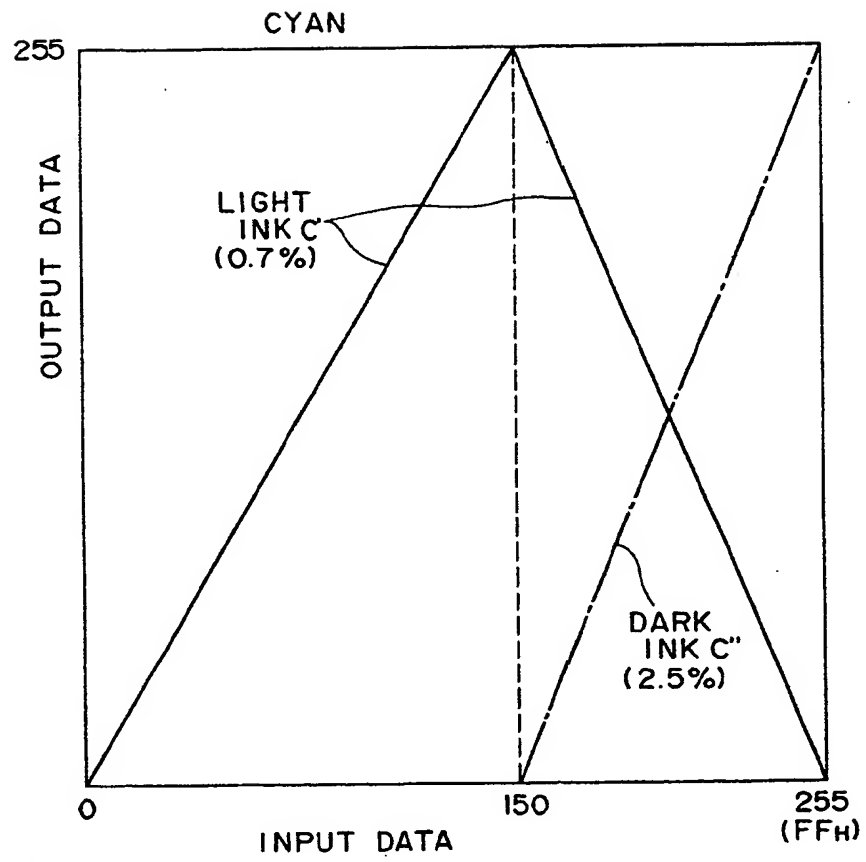


FIG. 3

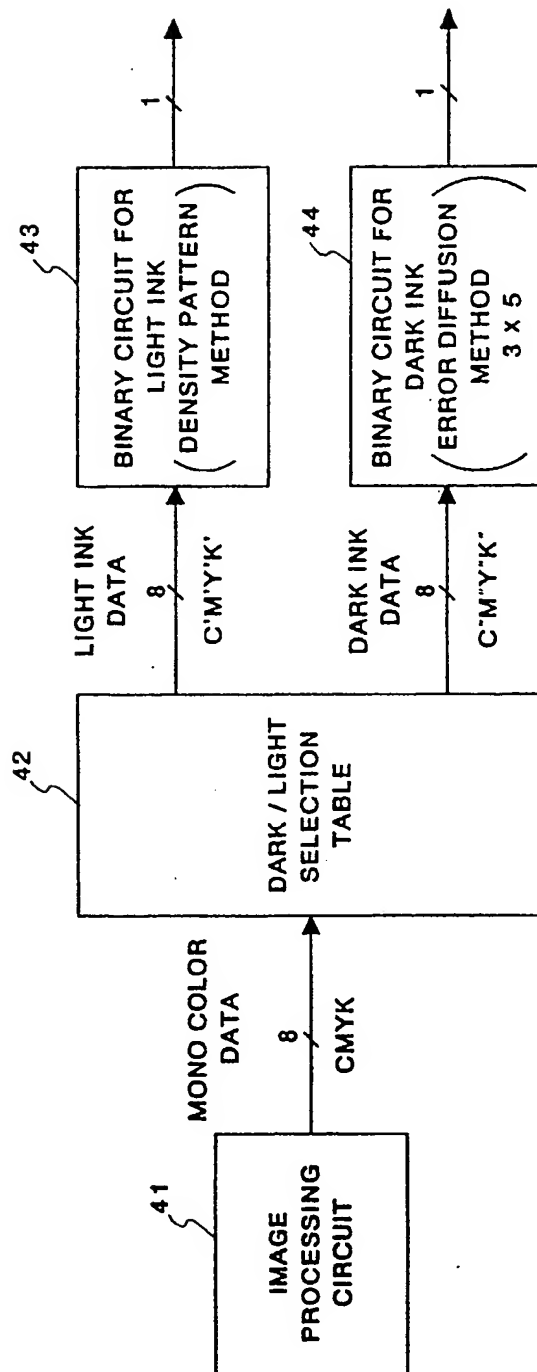


FIG. 4

5	3	1
7	5	3
*	7	5
	5	3
	3	1

FIG. 5

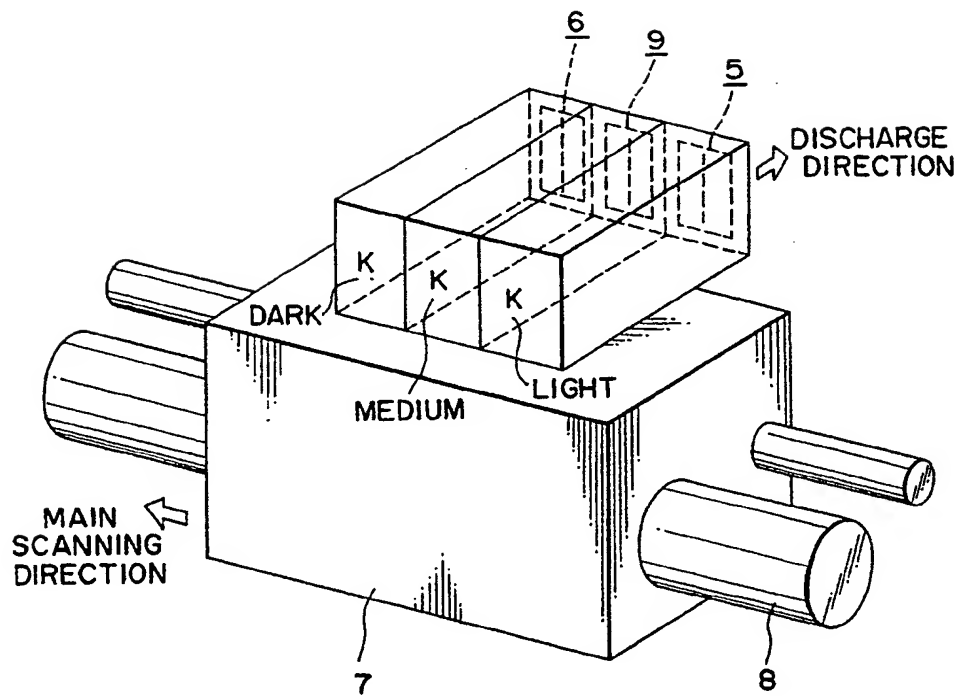


FIG. 6

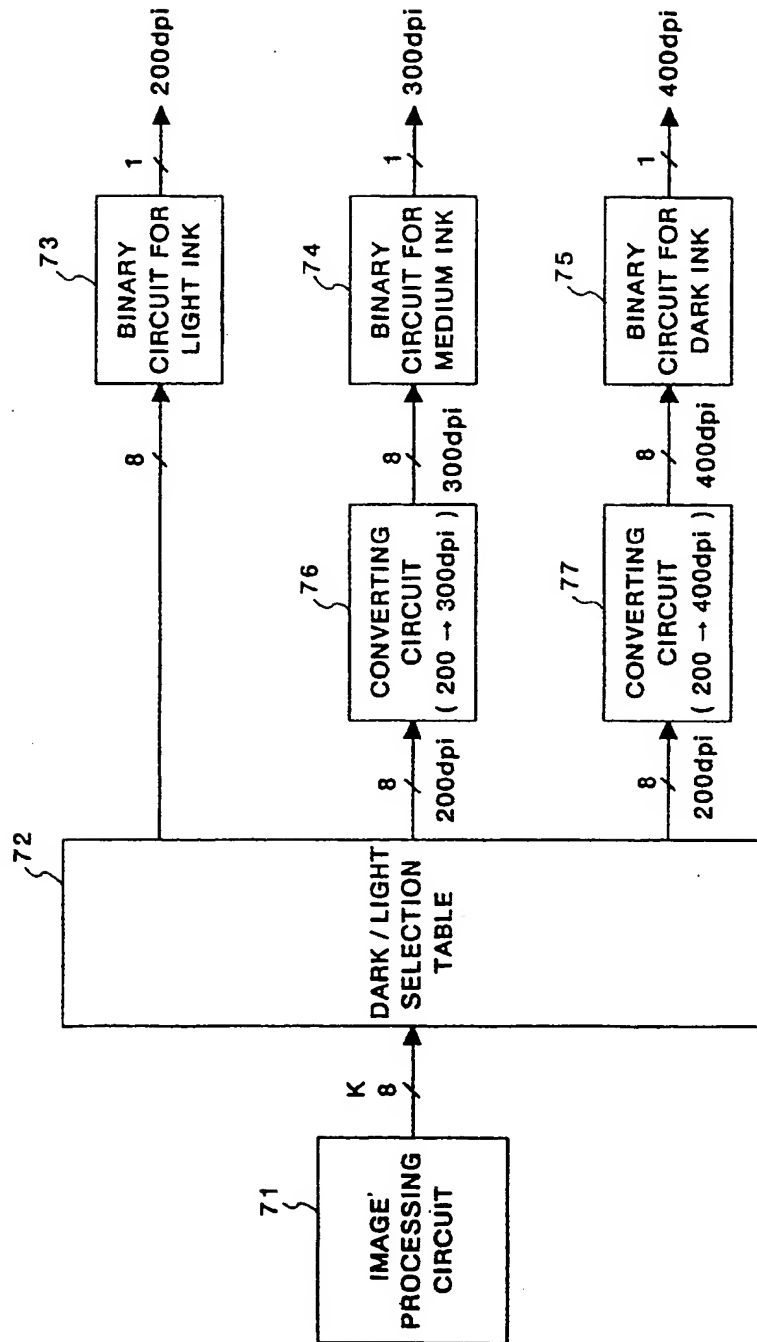


FIG. 7

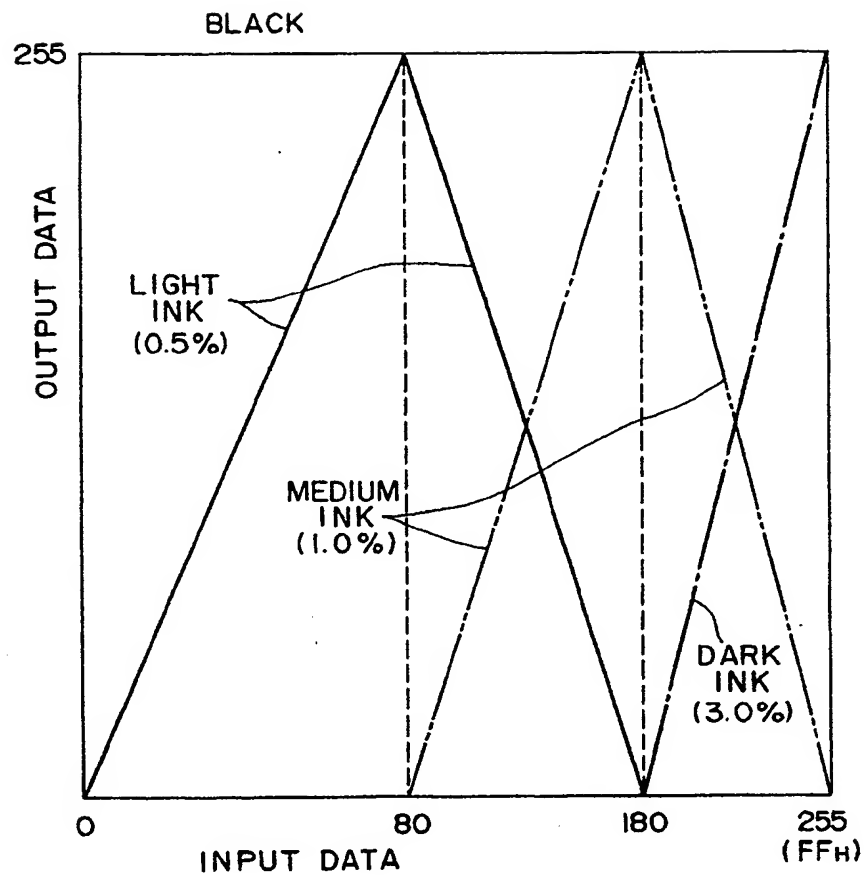


FIG. 8



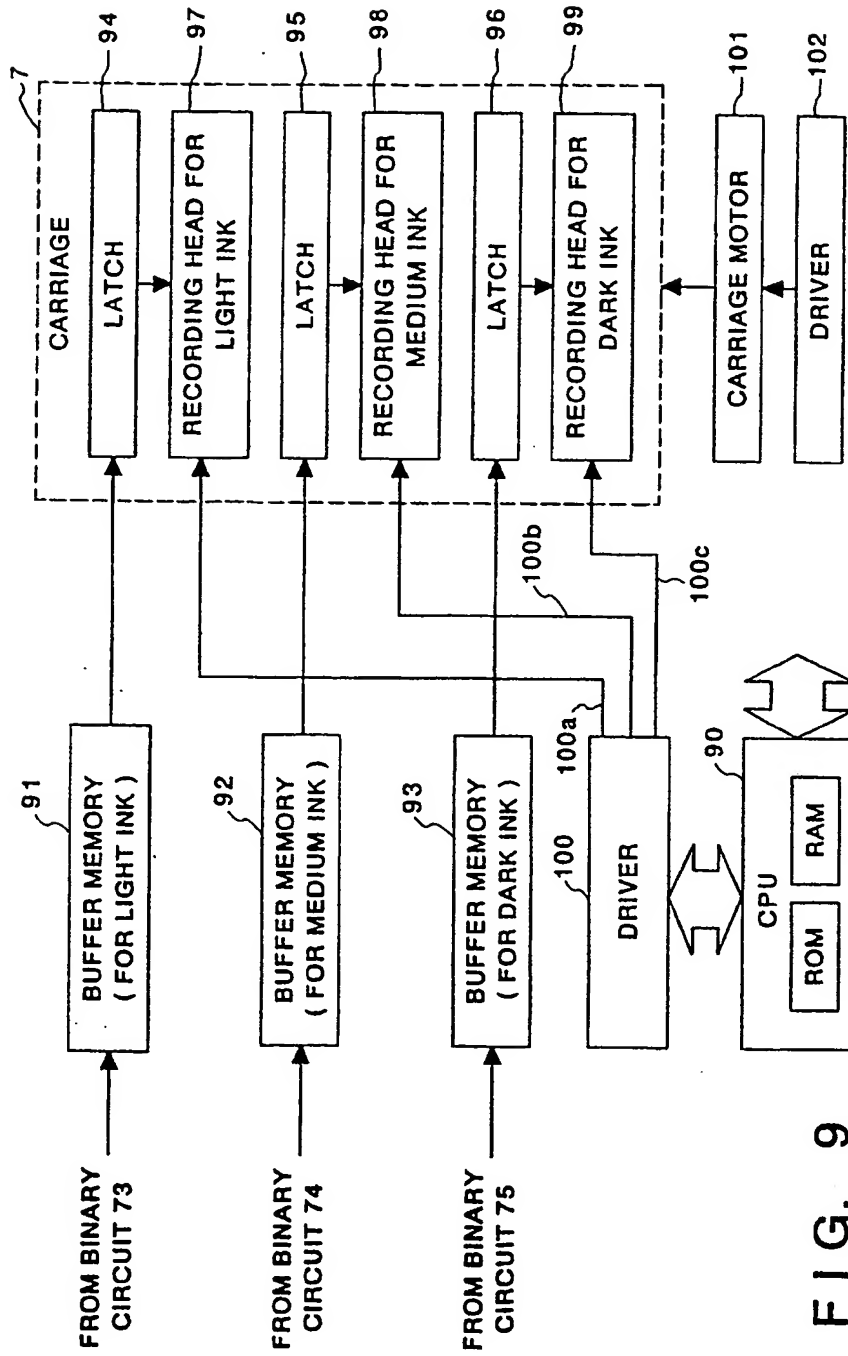
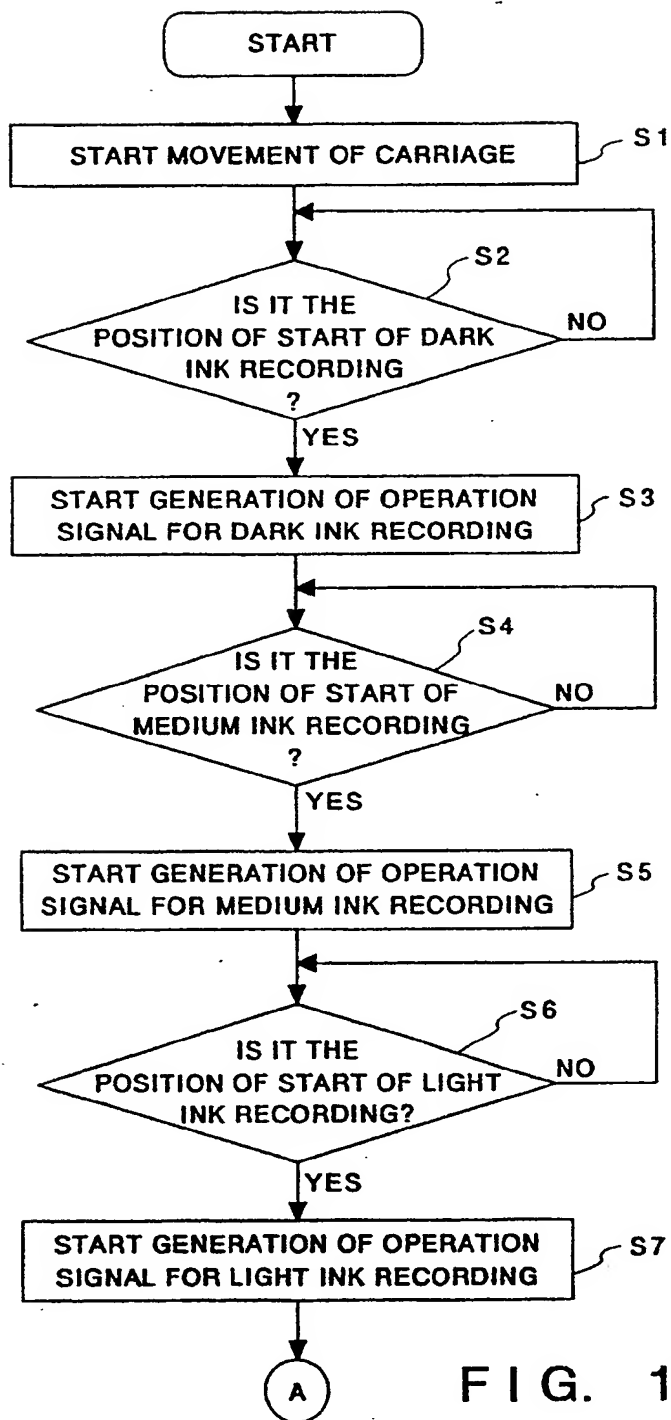


FIG. 9



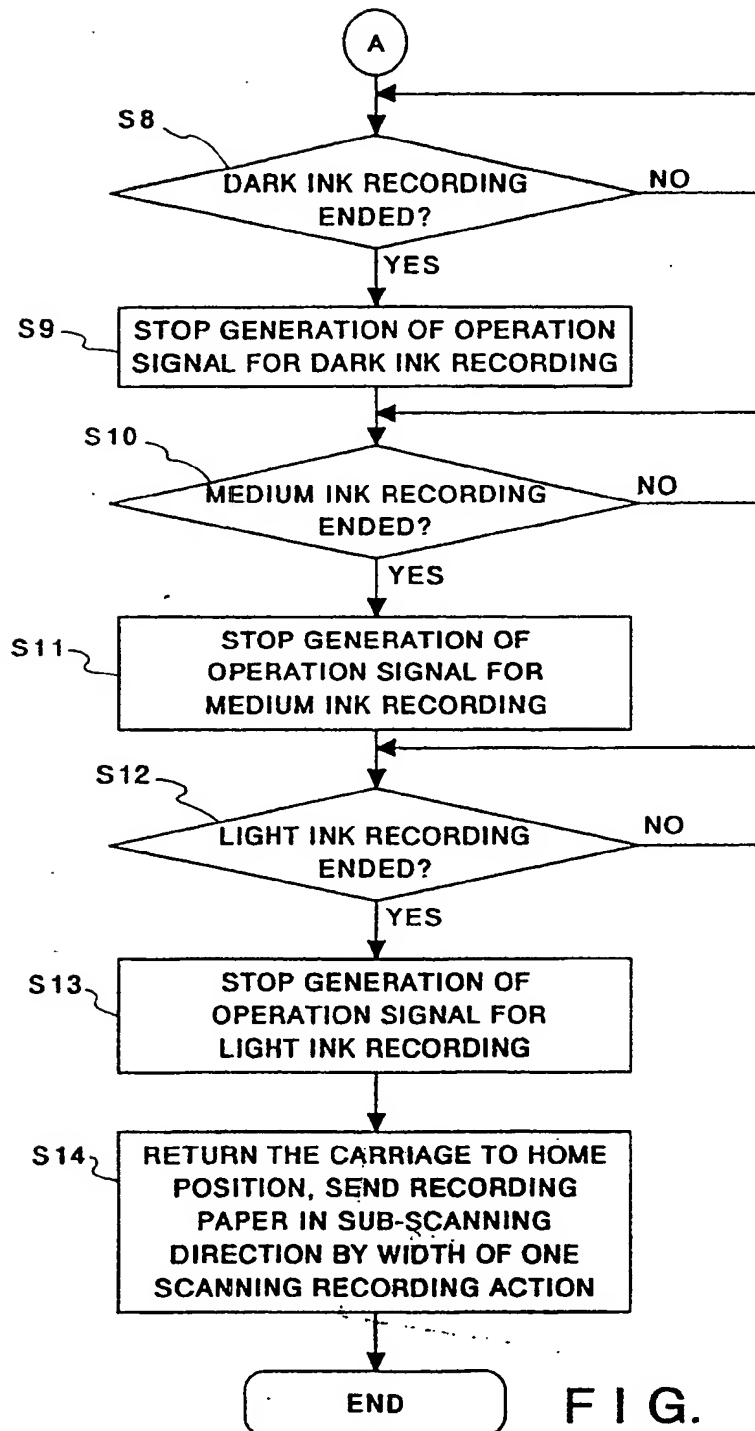


FIG. 10B

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Image recording system and apparatus therefor.

In order to record excellent gradient image by using ink of different densities, image data for dark ink and that for light ink are generated in accordance with the received image data. The generated data for dark ink is converted into a binary signal which is

suitable for reproducing the resolution, while data for light ink is converted to another binary signal which is suitable for expressing gradient. In accordance with these binary signals, the discharge of each ink is controlled so as to record the image.

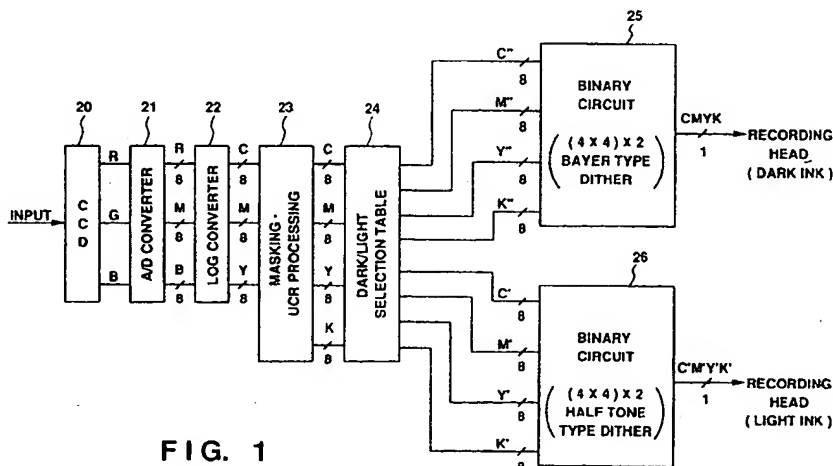


FIG. 1

EP 0 401 023 A3



European  
Patent Office

## EUROPEAN SEARCH REPORT

Application Number

EP 90 30 5956

DOCUMENTS CONSIDERED TO BE RELEVANT					
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)		
Y	EP-A-0 150 119 (NEC CORP.) * Whole document *	1,2	H 04 N 1/40		
A		3,7,8, 10-18,20, 21,24			
Y	EP-A-0 304 289 (TOSHIBA K.K.) * Abstract; page 1, lines 1-60 *	1,2			
A	IEEE TRANSACTIONS ON COMMUNICATIONS, vol. COM-29, no. 12, December 1981, pages 1898-1925, IEEE, New York, US; J.C. STOFFEL et al.: "A survey of electronic techniques for pictorial image reproduction" * Page 1904, left-hand column, line 16 - page 1908, left-hand column, line 35 *	7-9,17-19			
A	US-A-4 686 538 (KOUZATO) * Abstract; figures 1-3; column 1, line 1 - column 2, line 30 *	3-5,13, 14,19-24			
A	US-A-4 449 150 (KATO) * Column 3, line 40 - column 5, line 6 *	1-3,5-8, 17,18	TECHNICAL FIELDS SEARCHED (Int. Cl.5)		
A	DE-A-3 525 011 (CANON K.K.) * Abstract; claims 1-3; figures 1-3 *	1-24	H 04 N		
The present search report has been drawn up for all claims					
Place of search The Hague		Date of completion of search 08 November 91	Examiner FOGLIA P.		
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